Habitat Quality in the New York/New Jersey Harbor Estuary: An Evaluation of Pier Effects on Fishes

Final Report to the Hudson River Foundation

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Introduction:

Urban estuaries are focal points for human activities and they serve as nursery areas for a variety of juvenile fishes and crustaceans. These two potentially conflicting uses exist in an increasing number of systems, yet it is still unclear how these two factors interact. One question is whether man-made structures degrade natural environments or whether they act to supplement existing habitats. We investigated the roles of a variety of artificial structures, particularly piers, in the lower Hudson River to determine what effects, if any, piers and pier edges have on recently settled fishes. We evaluated these potential habitats using distribution, abundance and growth rate as measures of habitat quality.

Methods and Results:

Trapping

In 1995, the assemblage of fishes relative to municipal piers was examined using two approaches. First, we conducted a field trapping study to examine the abundance and diversity of organisms in each of three habitats, under a large pier, in a pile field area, and at an open water site. Second, we used a field caging technique to examine the effect of piers on growth rates of the juveniles of two target species, the winter flounder, *Pseudopleuronectes americanus*, and the tautog, *Tautoga onitis*, across the same three habitats. Data collected from this investigation indicated that diversity and abundance of fishes were depressed under piers (see Able et al. 1998), and that growth rates among juveniles of the target species were habitat-specific, with greater growth rates occurring among fishes caged in open water and pile field habitats than among fishes caged in under-pier areas (see Able at al. in press).

In 1996, our efforts were focused on the patterns of species abundance and distribution relative to one municipal pier with a concentration on the pier edge. The trapping survey for 1996 was honed to an under-pier, pier-edge, beyond-pier (open-water) ecotone. We also examined growth rates of juvenile winter flounder and juvenile tautog in caging studies (1996 and 1997) conducted along the same ecotone. Results from the growth studies indicate that growth rates of both winter flounder and tautog are negative under piers and are comparable to lab-starved controls. In contrast, mean growth rates at pier edges and in open water beyond piers were generally positive, with growth at piers edges often being more variable and less rapid than at open water sites (see Duffy-Anderson and Able 1999).

Trapping Results Across the Pier Edge (1996)

The number of species collected in the Hudson River during the study period was low compared to the number captured in 1995 (see Able et al. 1998). From June through October, only 20 different species of fish were captured, for a total of 270 individuals (Table 1). The most abundant fish species in the system was the American eel, *Anguilla rostrata*, of which 70 individuals, or 25.9% of the total fish catch, were obtained (Figure 1). Naked goby, *Gobiosoma bosc*, spotted hake, *Urophycis regia*, and Atlantic tomcod, *Microgadus tomcod*, also constituted a significant portion of the fish catch, comprising 15.9%, 14.8%, and 14.1% respectively.

Abundances of decapod crustaceans in the Hudson River were also low compared to abundances derived in 1995. Only three species of decapods were captured throughout the entire study, the grass shrimp, *Palaeomonetes pugio*, the sand shrimp, *Crangon septemspinosa*, and the blue crab, *Callinectes sapidus*. All three of these species were captured in greater numbers than fishes at all sites, and the total number of decapods caught reached 8405 individuals for the season. Grass shrimp were the single most abundant animal caught in the Hudson River, comprising 61.7% of the total animal catch.

Size and seasonal patterns of fishes

With the exception of the American eel, fishes collected during the study were generally small (Figure 2). Young-of-the-year individuals comprised a large portion (58%) of the total number of fishes captured confirming that the traps used in the study were well suited to the capture of juvenile forms. Juvenile conger eels were only captured during the month of June (Figure 3), and juvenile spotted hake were captured primarily in June (Figure 4). Juvenile Atlantic tomcod were found in high numbers from June through August (Figure 5), and juvenile striped bass were captured in greatest numbers in September (Figure 6).

Fish abundance and distribution

CPUE among fishes across the pier ecotone varied with species. For example, among American eel and Atlantic tomcod, CPUE tended to be higher in the under pier habitat than edge or open water areas (Figure 7). Spotted hake were occasionally found under Pier A, though mean CPUE was higher in edge and open water areas. No other fish species were found under Pier A, therefore CPUE among all other fish species was higher at either pier edge or open water habitats compared to under pier sites.

Distribution of decapod crustaceans

Blue crab adults and juveniles were collected during the study, with adults being present in the collections throughout the study and a cohort of juvenile blue crabs appearing in September (Figure 8). *P. pugio* and *C. septemspinosa* were collected throughout the duration of the study. All three species of decapods were captured at all sites along the pier transects however, mean decapod CPUE was higher at pier edge and open water sites compared to under pier areas (Figure 9).

Statistical Analyses - Trapping Study

A two-way crossed ANOSIM analysis examining the effects of site (-40 m, -20 m, 0 m, +20 m, +40 m) and transect (Near, Far) revealed no significant differences in fish assemblage between the two transects ($p = 0.61$). However, the analysis did reveal a significant difference in assemblage with site ($p < 0.01$) (Table 2). Assemblages at sites under Pier A were different from sites at the pier edge and sites beyond the pier, though the two under-pier sites were not significantly different from one another and edge and beyond pier sites were not significantly different from one another. A s there were no significant differences between the two transects, the data were pooled to an under pier habitat, a pier edge habitat, and a beyond pier habitat and re-analyzed using a one-way ANOSIM test. Results were similar to that of the previous analysis and suggested that there were significant differences in fish distribution relative to the pier ($p < 0.05$). Multiple comparison tests again indicated that the fish assemblages under Pier A were different from assemblages at edge sites and open water sites while the assemblages at edge and open water sites were not significantly different from one another.

The n-m MDS ordination suggested that several collections from open water and edge sites were different in their faunal assemblages than all other habitats (Figure 10a). These samples contained lone individuals of species that were never captured again in the study at any site (weakfish, *Cynoscion regalis*, summer flounder, *Paralicthys dentatus*, crevalle jack, *Caranx hippos*, and small mouth flounder, *Etropus microstomus*). When the ordination was repeated without these four samples (Figure 10b), it was determined that samples derived from under pier sites tended to be grouped together more closely than samples derived from edge or open water areas lending support to the observation that under-pier sites supported a different fish assemblage than edge or open water sites. Stress coefficients calculated from the procedure indicated that the ordination gave an excellent representation with little possibility of misrepresentation (stress = 0.01).

Similarity percentages were calculated to: A) determine the relative similarity of the fish assemblages within each habitat over time, B) determine the contribution of each fish species to the overall similarity of the three habitats, and C) determine the dissimilarity in assemblage between each of the three habitats. The analysis indicated that under pier areas were generally more similar in their species composition across replicate samples (49% similarity) than pier edge or beyond pier open water areas (17% and 19% respectively), indicating that under pier areas were less diverse in their species assemblage. American eels were principally responsible for the similarity in species composition under the pier, and naked gobies contributed the most to similarity at edge and open water habitats. Percent dissimilarity among the three habitats was low but relatively uniform, with each of the three habitats being approximately 80% distinct from one another.

Conclusions:

Results from this series of experiments indicate that under-pier environments may be poor-quality habitats from some species of juvenile fish. Fish abundance is depressed under piers compared to pile field and open water areas (Able et al. 1998) and growth rates under piers are also depressed (Able et al. in press, Duffy-Anderson and Able 1999). Since poor growth rates may decrease survival, we suggest that large pier structures may be detrimental to recruitment.

Literature Cited:

Able, K. W., Manderson, J. P. and Studholme, A. L. 1998. The distribution of shallow water juvenile fishes in an urban estuary: the effects of man-made structures in the lower Hudson River. Estuaries: 21(4b) 731-744.

Able, K. W., Manderson, J. P. and Studholme, A. L. In press. Habitat quality for shallow water fishes in an urban estuary: the effects of man-made structures on growth. *Mar Ecol. Prog Ser.*

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Table 1. Common and scientific names of fishes and crustaceans collected in 1996.

Common Name	**Scientific Name**	**Number collected**
Fishes		
American eel	***Anguilla rostrata***	**70**
Naked goby	***Gobiosoma bosc***	**43**
Spotted hake	***Urophycis regia***	**40**
Atlantic tomcod	***Microgadus tomcod***	**38**
Conger eel	***Conger oceanicus***	**34**
Striped bass	***Morone saxatilis***	**14**
Winter flounder	***Pseudopleuronectes americanus***	**10**
Northern pipefish	***Sygnathus fuscus***	**9**
Other (n = 12)		**12**
Total Fishes		**270**
Decapods		
Grass shrimp	***Palaemonetes pugio***	**5356**
Sand shrimp	***Crangon septemspinosa***	**2786**
Blue crab	***Callinectes sapidus***	**263**
Total Decapods		**8405**

Table 2. Results of a 2-way crossed ANOSIM examining the effects of transect and station on distribution and abundance of juvenile fish.

A.

Factor	**Global *R***	***p* value**
Transect	-0.009	0.61
Station	0.052	0.01

B.

Factor	**Global *R***	***p* value**
Station	0.146	<0.001

C.

Group	***p* value**
Under Pier vs. Pier Edge	<0.001
Under Pier vs. Beyond Pier	<0.001
Pier Edge vs. Beyond Pier	0.45

Figure 1. Percent contribution to the total fish assemblage (1996).

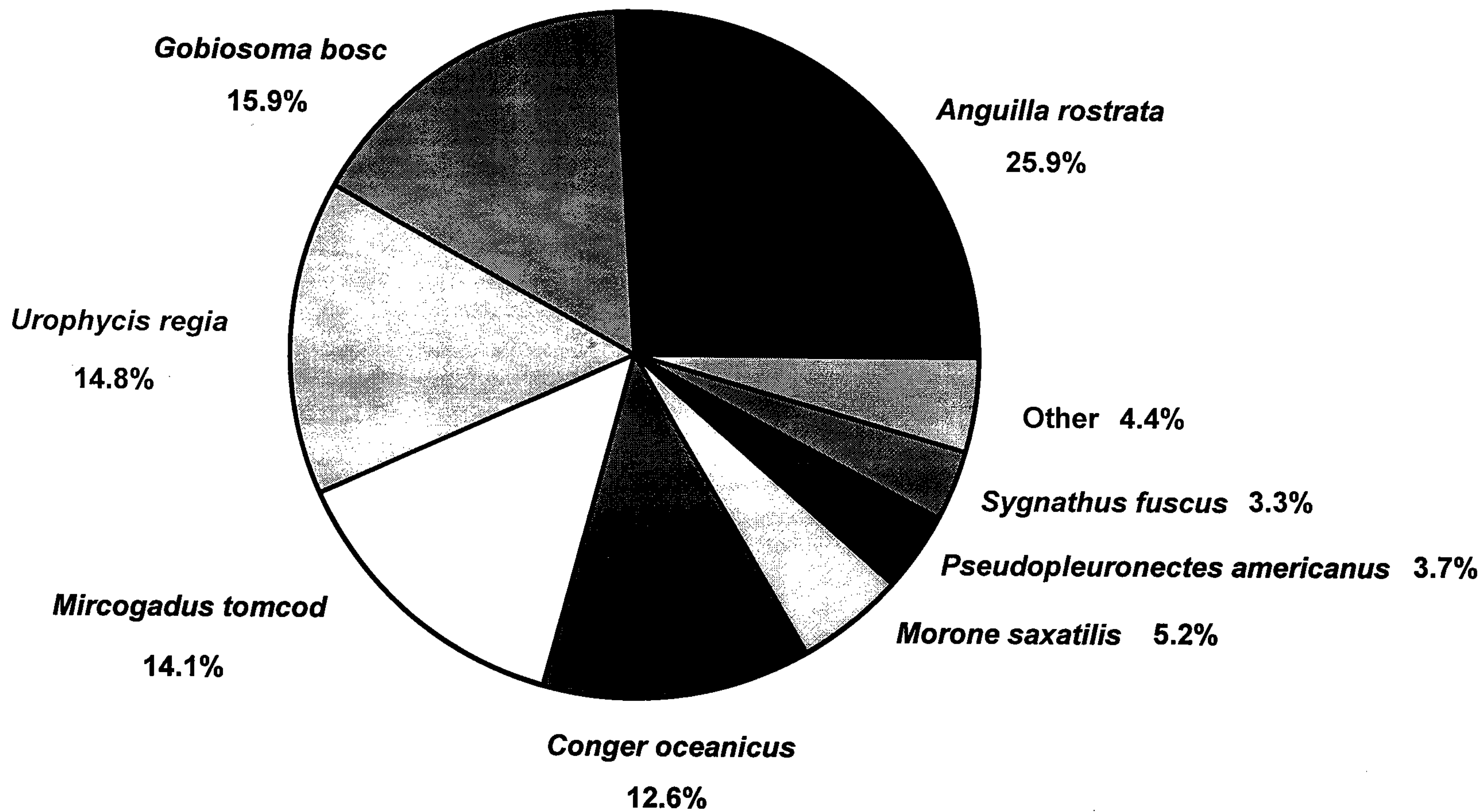


Figure 2. Length-frequency distribution of fishes collected in the Hudson River in 1996.

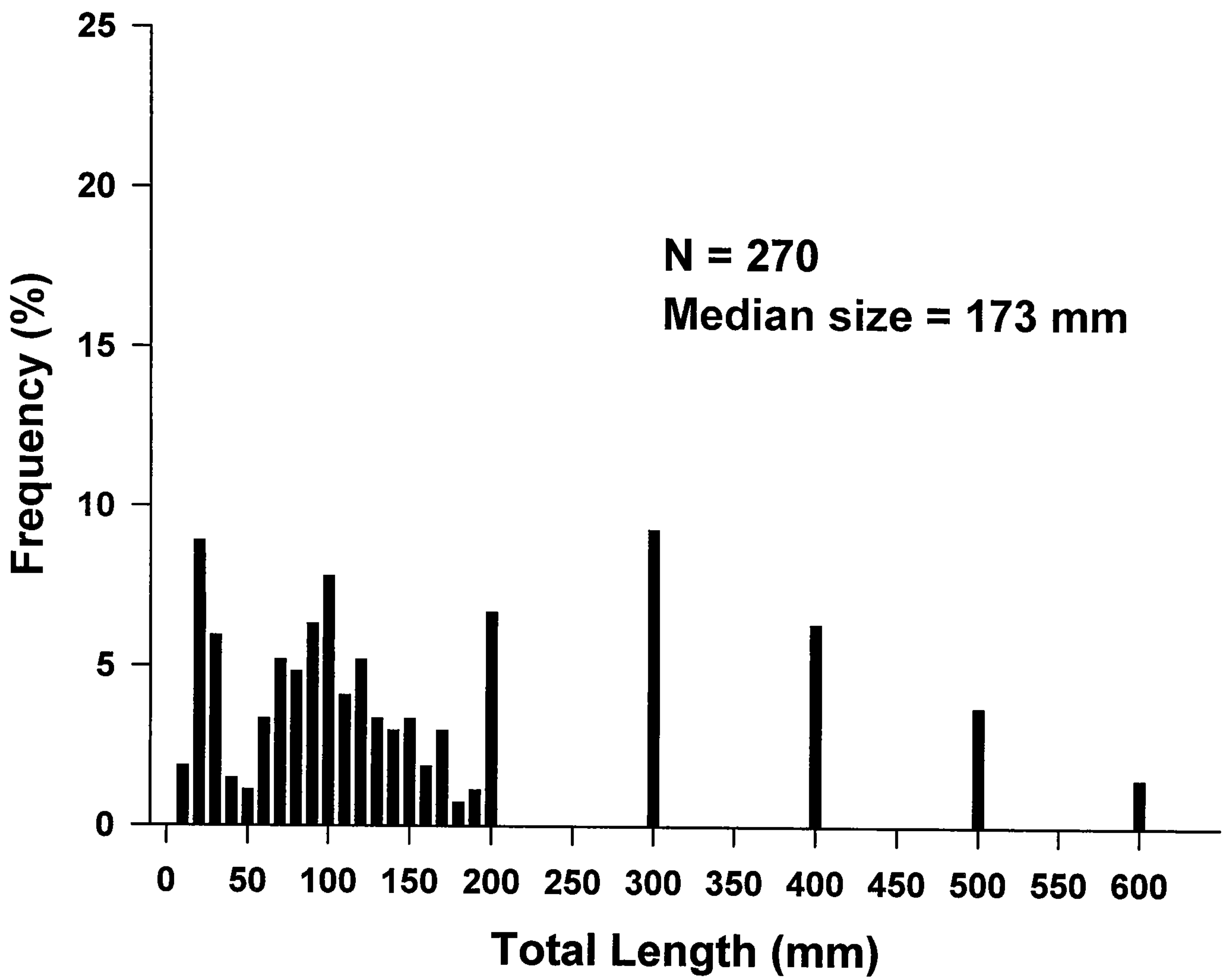


Figure 3. Length-frequency distribution of conger eel

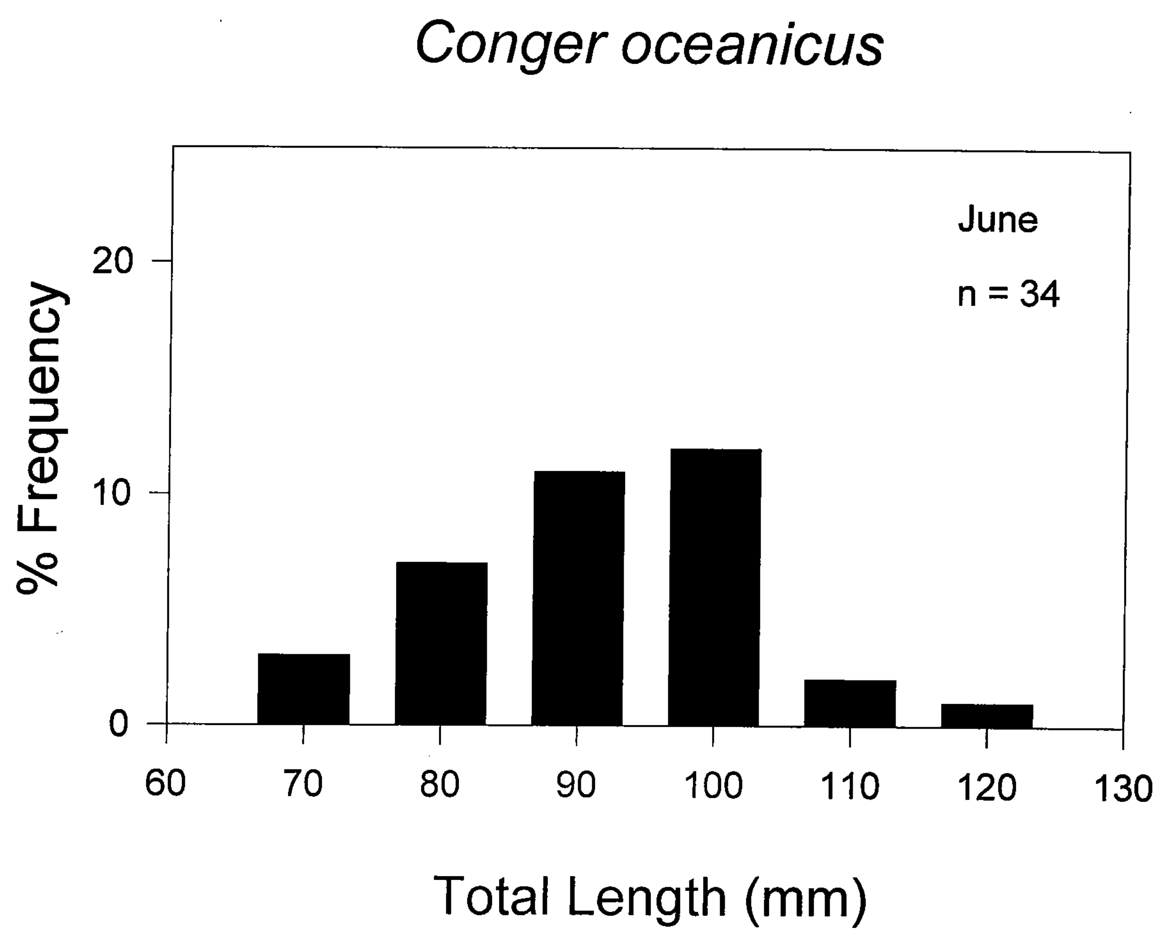


Figure 4. Length-frequency distribution of spotted hake

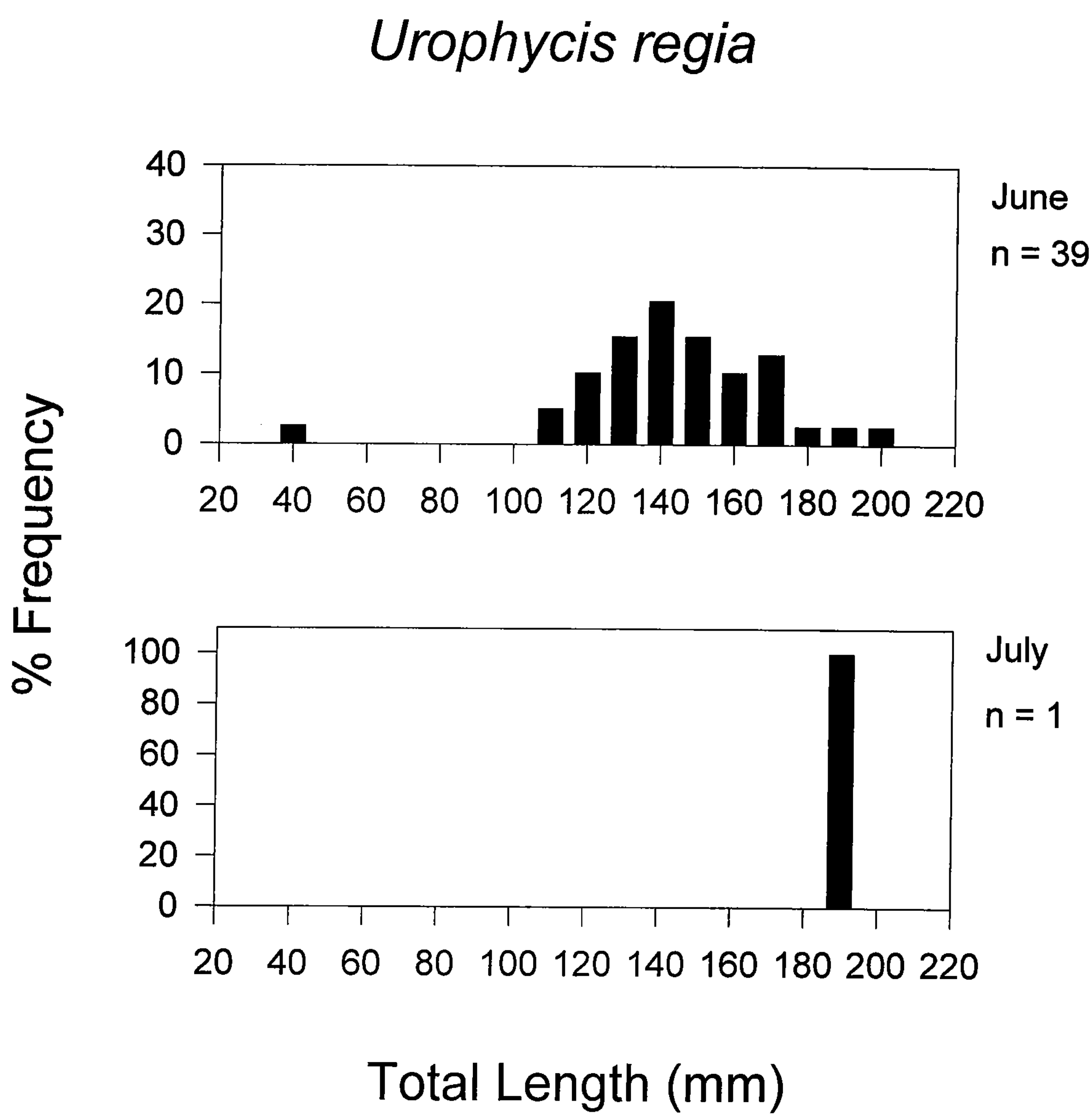


Figure 5. Length-frequency distribution of Atlantic tomcod

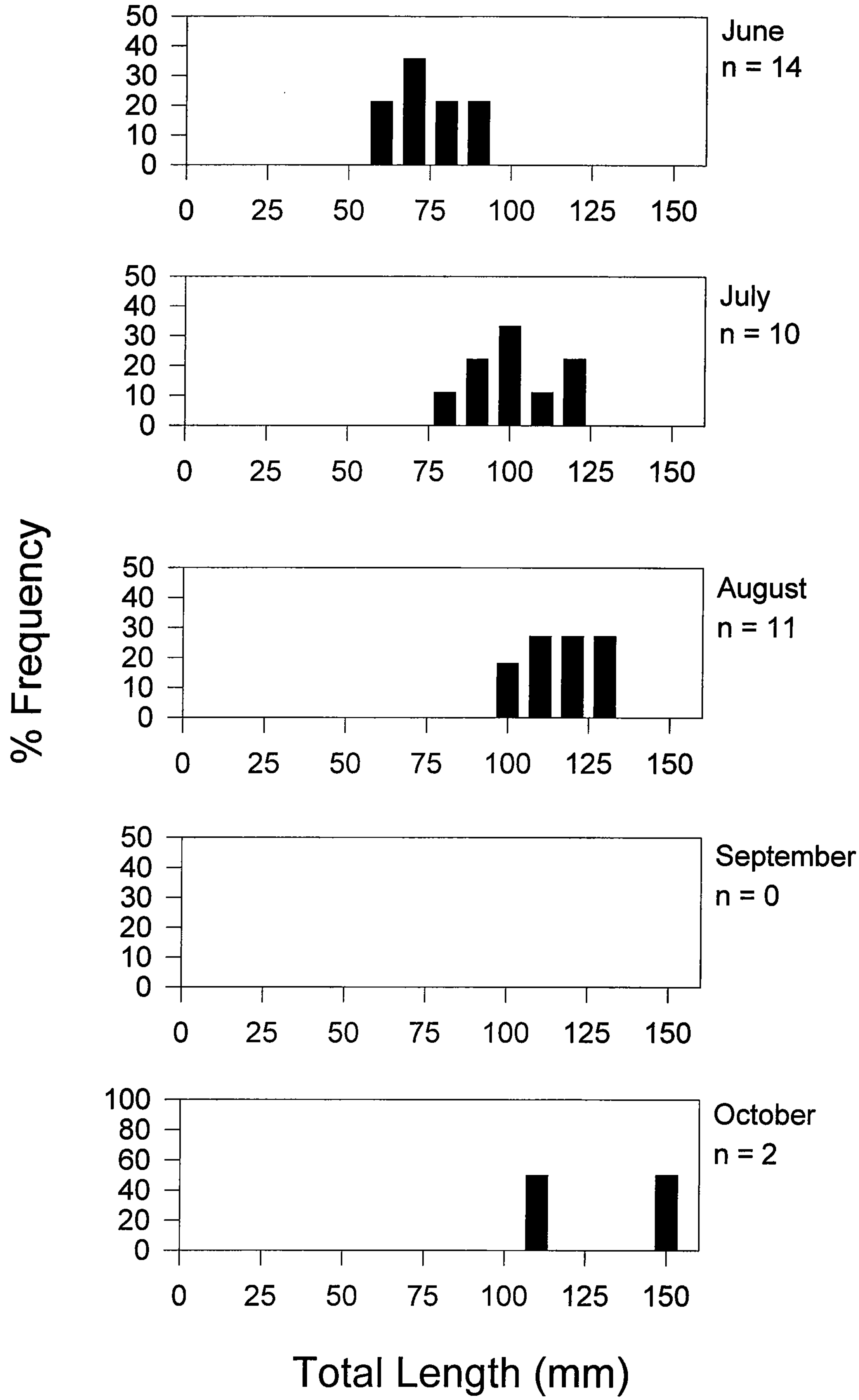


Figure 6. Length-frequency distribution of striped bass.

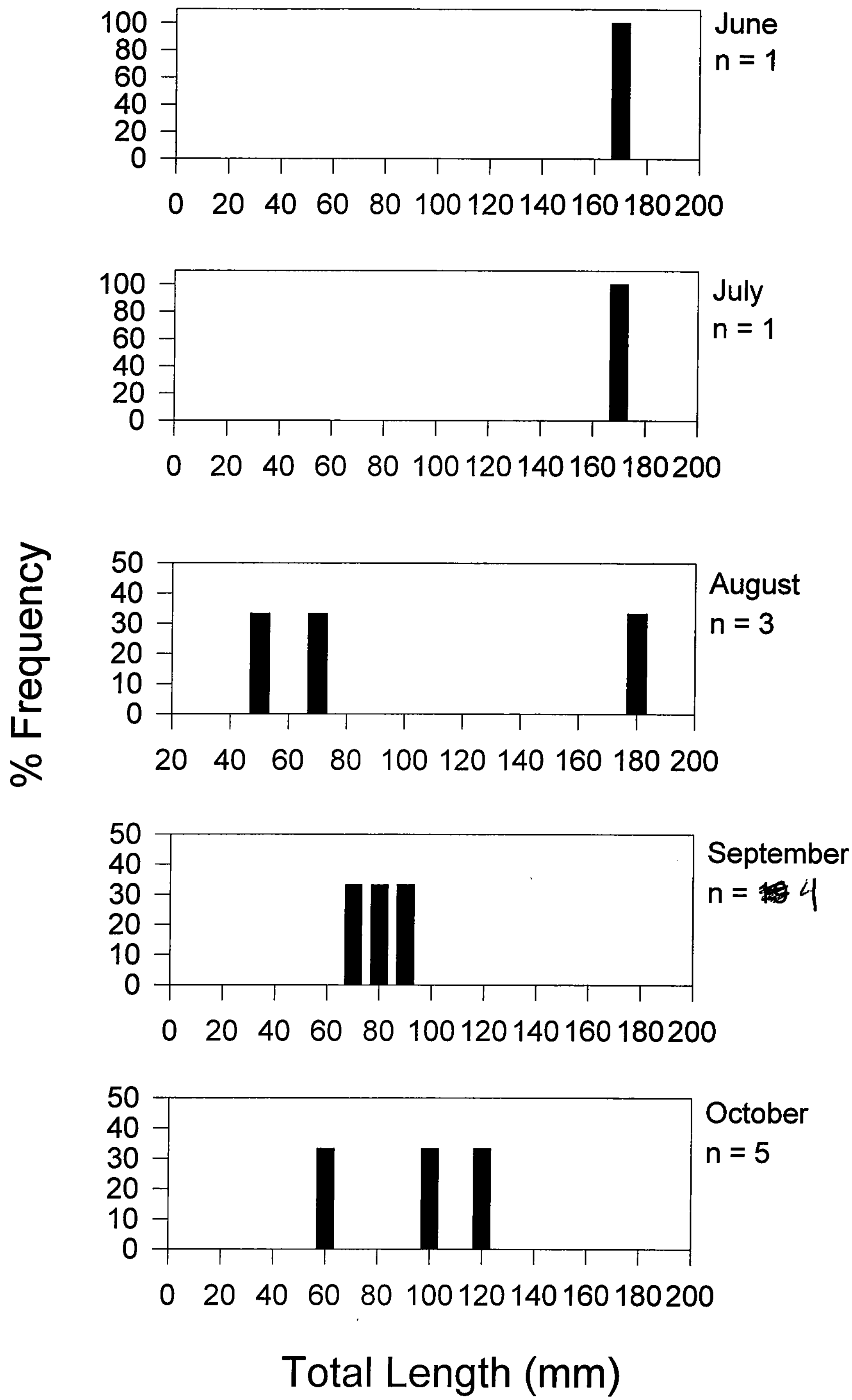


Figure 7. Fish CPUE across the pier ecotone.

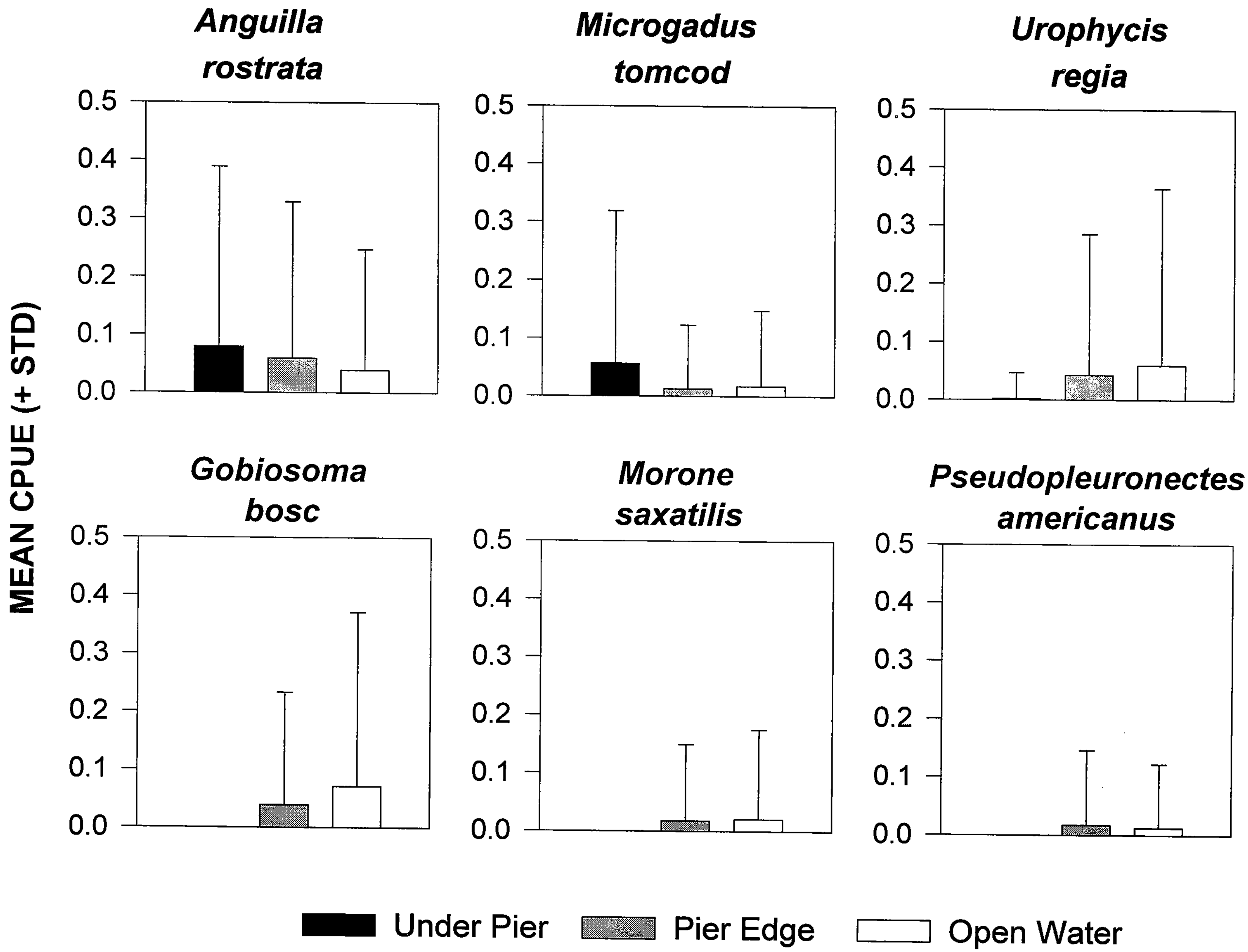


Figure 8. Carapace width-frequency distribution of blue crabs.

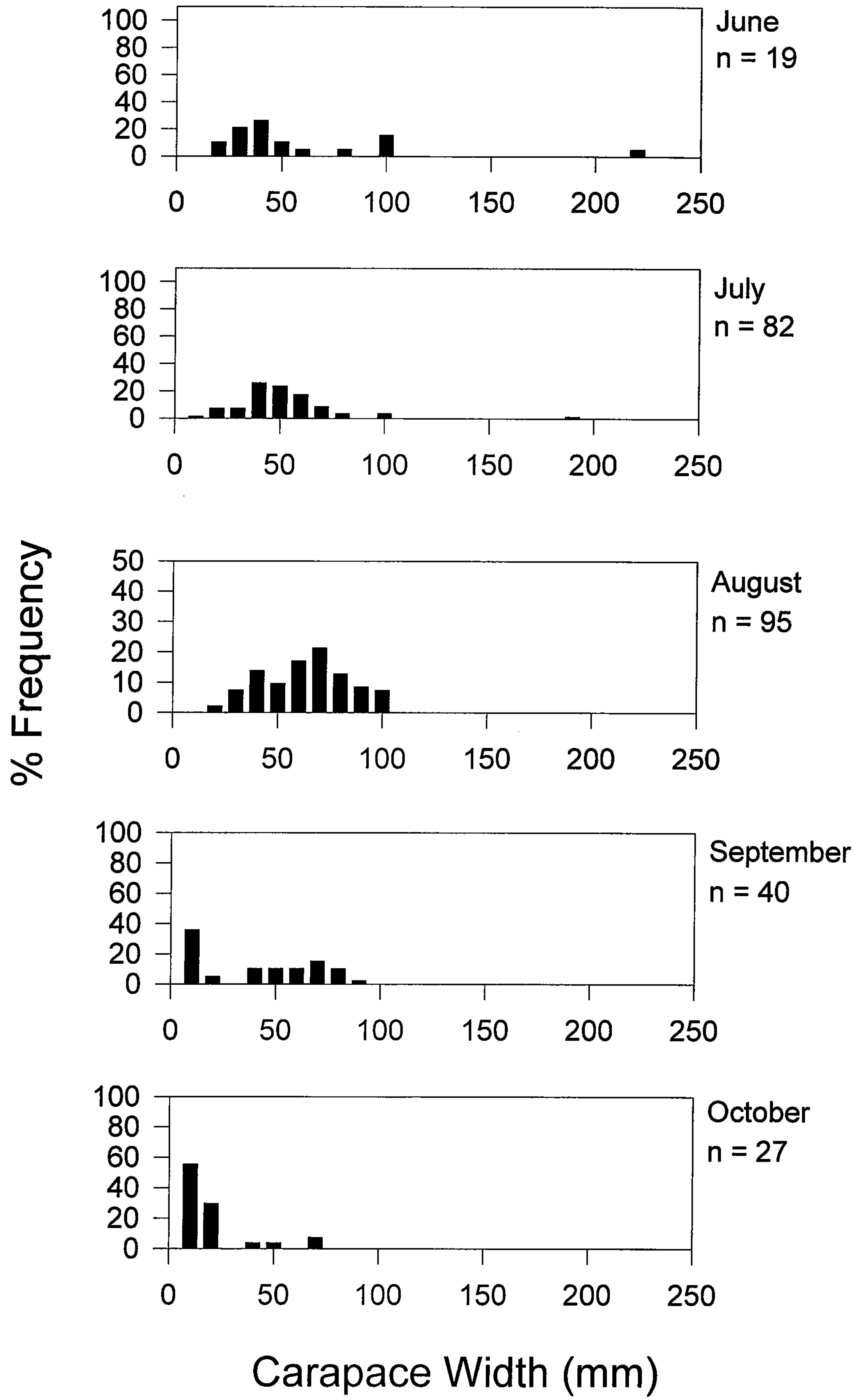


Figure 9. Decapod CPUE across the pier ecotone.

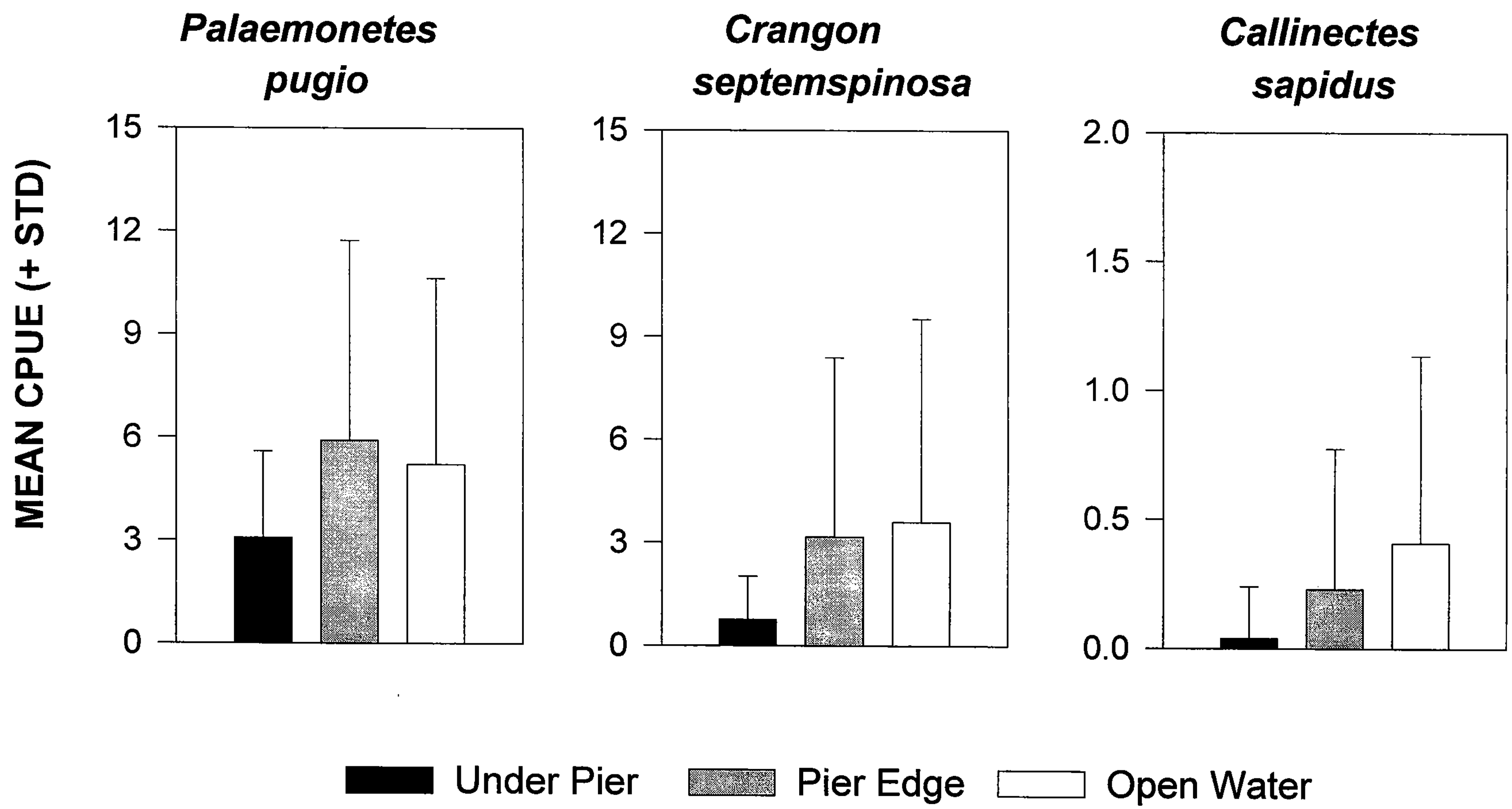
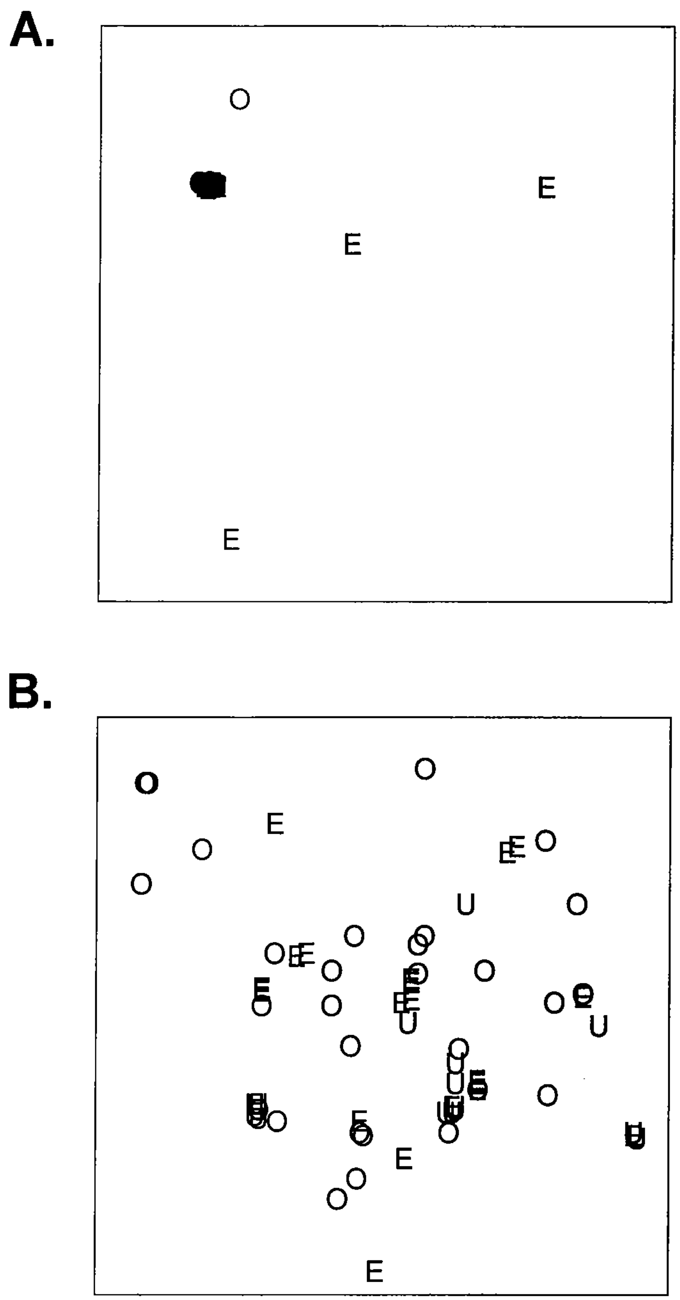


Figure 10. Patterns of fish distribution based on non-metric multi-dimensional scaling.



U = Under Pier

E = Pier Edge

O = Open Water